REMARKS

Claims 11-21 are pending in this application. The Office Action withdraws claims 18-20 as being drawn to a non-elected invention; rejects claims 11-12 and 14 under 35 U.S.C. §102(b); and rejects claims 13, 15-17 and 21 under 35 U.S.C. §103(a). Applicants respectfully traverse the rejections.

I. Restriction Requirement

Claims 18-20 are withdrawn as being drawn to a non-elected invention. Applicants hereby affirm the election of Group I (claims 11-17 and 21), with traverse.

National stage applications filed under 35 U.S.C. §371 are subject to unity of invention practice as set forth in PCT Rule 13, and are not subject to U.S. restriction practice. *See* MPEP §1893.03(d). PCT Rule 13.1 provides that an "international application shall relate to one invention only or to a group of inventions so linked as to form a single general inventive concept." PCT Rule 13.2 states:

> Where a group of inventions is claimed in one and the same international application, the requirement of unity of invention referred to in Rule 13.1 shall be fulfilled only when there is a technical relationship among those inventions involving one or more of the same or corresponding special technical features. The expression "special technical features" shall mean those technical features that define a contribution which each of the claimed inventions, considered as a whole, makes over the prior art.

A lack of unity of invention may be apparent "*a priori*," that is, before considering the claims in relation to any prior art, or may only become apparent "*a posteriori*," that is, after taking the prior art into consideration. *See* MPEP §1850(II), quoting *International Search and Preliminary Examination Guidelines* ("ISPE") 10.03. Lack of *a priori* unity of invention only exists if there is no subject matter common to all claims. *Id.* If *a priori* unity of invention exists between the claims, or, in other words, if there is subject matter common to

all the claims, a lack of unity of invention may only be established *a posteriori* by showing that the common subject matter does not define a contribution over the prior art. *Id.*

Furthermore, unity of invention only needs to be determined in the first place between independent claims, and not the dependent claims, as stated in ISPE 10.06:

> Unity of invention has to be considered in the first place only in relation to the independent claims in an international application and not the dependent claims. By "dependent" claim is meant a claim which contains all the features of one or more other claims and contains a reference, preferably at the beginning, to the other claim or claims and then states the additional features claimed (Rule 6.4).

See also MPEP §1850(II). ISPE 10.07 further provides:

> If the independent claims avoid the prior art and satisfy the requirement of unity of invention, no problem of lack of unity arises in respect of any claims that depend on the independent claims. In particular, it does not matter if a dependent claim itself contains a further invention.

See also MPEP §1850(II).

The claims of Group I (11-17 and 21) are all directed to a coating for a mechanical part, that is made up of the recited layers. The claims of Group II (18-20) are directed to methods of manufacturing that coating, through the recited plasma enhanced chemical vapor deposition.

Accordingly, all the claims share common subject matter of a coating for a mechanical part that is made up of the recited amorphous silicon carbide and amorphous carbon and, therefore, *a priori* unity of invention exists between all the claims. Thus, for the present application, a lack of unity of invention may only be determined *a posteriori*, or in other words, after a search of the prior art has been conducted and it is established that all the elements of the independent claim are known. *See* ISPE 10.07 and 10.08.

The Office Action does not establish that each and every element of the subject matter that is common to independent claim 11 is known in the prior art, as discussed below.

Therefore, Applicants respectfully submit that lack of unity of invention has not been established, and thus a restriction requirement based on a lack of unity of invention is improper.

Thus, withdrawal of the Restriction Requirement is respectfully requested.

In any event, where product and process claims are presented in the same application, Applicants may be called upon under 35 U.S.C. §121 to elect claims to either the product or process. MPEP §821.04. However, in the case of an elected product claim, rejoinder will be permitted when a product claim is found allowable and the withdrawn process claim depends from or otherwise includes all the limitations of an allowed product claim. Id.

In the present application, the method claims of Group II include all of the limitations of the product of Group I. In particular, all of the limitations of the independent product claim 11 of Group I are incorporated into dependent method claim 18 of Group II. Since the method claims of Group II include the limitations of the product claims of Group I, the method claims must be rejoined with the product claims once the product claims are allowed. Therefore, because the product claims are allowable (as discussed below), Applicants hereby request rejoinder of claims 18-20

II. Rejections over Rogers

Claims 11-12 and 14 are rejected under 35 U.S.C. §102(b) as being anticipated by Rogers (WO 00/47290). Claims 13, 15-17 and 21 are rejected under 35 U.S.C. §103(a) as having been obvious over Rogers. The rejections will be discussed simultaneously as they are both based on Rogers. Applicants respectfully traverse the rejections.

Applicants respectfully submit that Rogers does not disclose, nor teach or suggest, all the features of independent claim 11. Specifically, Rogers at least fails to disclose, or teach or suggest, a coating that includes amorphous silicon carbide. Instead, Rogers merely discloses a coating that includes amorphous carbon *that is doped with silicon*. See Rogers at,

for example, page 3, line 30. The Office Action asserts that "the Si-DLC is considered to read on applicant's hydrogenated amorphous silicon carbide layer." Applicants respectfully submit that this is not the case.

As is discussed in the present specification, at least at page 7, lines 13-24, hydrogenated amorphous silicon carbide only has covalent Si-C, C-H and Si-H bonds and no C-C bonds. "Hydrogenated amorphous silicon carbide must therefore *not* be structurally mistaken for a *silicon-doped* hydrogenated amorphous carbon, comprising, in particular sp^2 and sp^3 type C-C bonds" (emphasis added). Therefore, hydrogenated amorphous silicon carbide has *an entirely different chemical structure* than silicon-doped hydrogenated amorphous carbon. The article to J.Huran, "Properties of amorphous silicon carbide films prepared by PECVD," cited in the present specification at page 7, lines 18-20, is attached as further proof of this fact. Applicants respectfully note that Rogers is specifically distinguished on this basis in the present specification at page 2, lines 10-22.

Furthermore, as further support for this argument, enclosed is the opinion of the International Searching Authority. The opinion of the International Searching Authority states that "[h]ydrogenated amorphous silicon carbide is distinguished essentially from silicon-doped hydrogenated amorphous carbon in that is contains not C-C bonds but rather Si-C, C-H and Si-H bonds."

Accordingly, the Si-DLC of Rogers does *not* read on the presently claimed hydrogenated amorphous silicon carbide, nor would the hydrogenated amorphous silicon carbide have been obvious therefrom, because the compounds at issue have entirely different chemical structures. Therefore, independent claim 11 is patentable over Rogers for at least the reasons discussed above. Dependent claims 12-17 and 21 are therefore also patentable over Rogers for at least the reason that independent claim 11 is patentable.

Reconsideration and withdrawal of the rejection are respectfully requested.

III. Conclusion

In view of the foregoing, it is respectfully submitted that this application is in condition for allowance. Favorable reconsideration and prompt allowance of the application are earnestly solicited.

Should the Examiner believe that anything further would be desirable in order to place this application in even better condition for allowance, the Examiner is invited to contact the undersigned at the telephone number set forth below.

Respectfully submitted,

William P. Berridge
Registration No. 30,024

Samuel T. Dangremond
Registration No. 60,466

WPB:STD/std

Enclosures:
J. Huran, "Properties of Amorphous Silicon Carbide Films Prepared by PECVD", Vacuum, vol. 47, no. 10, pages 1223 to 1225 (1996).
Opinion of the International Searching Authority

Date: June 30, 2008

OLIFF & BERRIDGE, PLC
P.O. Box 320850
Alexandria, Virginia 22320-4850
Telephone: (703) 836-6400

DEPOSIT ACCOUNT USE AUTHORIZATION
Please grant any extension necessary for entry;
Charge any fee due to our Deposit Account No. 15-0461

DD2519

Pergamon

Vacuum/volume 47/number 10/pages 1223 to 1226/1996

0042-207X/96 $15.00+.00

PII: S0042-207X(96)00128-6

Properties of amorphous silicon carbide films prepared by PECVD*

J Huran,[a] L Hrubcin,[a] A P Kobzev[b] and J Lidoy,[c] *[a]Institute of Electrical Engineering, Slovak Academy of Sciences, 84239 Bratislava, Dúbravská cesta 9, Slovakia; [b]Laboratory of Neutron Physics, Joint Institute for Nuclear Research, 141980 Dubna, Russian Federation; [c]Faculty of Electrical Engineering, Slovak Technical University, Ilkovičova 3 81219 Bratislava, Slovakia*

received 20 November 1995

Amorphous SiC was prepared by plasma enhanced chemical vapour deposition of SiH_4 and CH_4. The properties of the SiC deposits were studied using a combination of infrared (IR), RBS, ERD (electron recoiling detection) and AES measurement. Infra red spectra showed the presence of Si–C, Si–H and C–H bonds. The compositions of the silicon, carbon and hydrogen in the films were found to be dependent on the preparation conditions. Copyright © 1996 Published by Elsevier Science Ltd

Introduction

Hydrogenated amorphous silicon carbide (a-$Si_{1-x}C_x$:H) films have been under intense research since their successful preparation using the rf glow discharge technique.[1] Silicon carbide is an important material for potential applications in photoelectronics, high temperature semiconducting devices, hard wear resistant coatings and protective barriers for corrosion or thermal oxidation. All these applications are due to its unique properties such as wide band gap, high electron mobility, high thermal conductivity and high melting point. Furthermore, SiC can also be used as a thin buffer layer for the growth of diamond films on silicon substrates.[2] For example a-$Si_{1-x}C_x$:H was used as a wideband window material to enhance the conversion efficiency of amorphous solar cells.[3] The significance of this material is that its electrical and optical properties can be controlled by varying the carbon, silicon and hydrogen composition of the film.

In the present article, an investigation is focused on the structural properties of a-$Si_{1-x}C_x$:H films prepared by the plasma enhanced chemical vapor deposition (PECVD) of silane SiH_4 and methane CH_4 using IR, RBS, ERD and AES measurement.

Experimental

Amorphous silicon carbide films were deposited on bare silicon substrates in a high frequency parallel-plate plasma reactor, with the frequency, rf power and substrate temperature maintained at 13.56 MHz, 0.06 Wcm^{-2} and 350°C, respectively. The electrode diameters were 12 cm and they were 4 cm apart. The rf power was fed to the upper electrode, while the lower electrode which held the substrates, was grounded. The gas mixture of SiH_4 and CH_4 was directly introduced into the reaction chamber, and the gas flow rates were 10 sccm and 40 sccm, respectively. Hydrogen concentration was determined by the ERD method. For this purpose the $^4He^+$ ion beam from the Van de Graaff accelerator of JINR in Dubna has been applied. An ion energy of 2.4 MeV was chosen with the target tilted at an angle 15° with respect to the beam direction and the recoiled protons measured forward at an angle of 30°.

Results and discussion

The infrared spectra of amorphous silicon carbide films were obtained using a Fourier transform infrared spectrometer (FTIR-8101M Shimadzu). Figure 1 shows the spectra of samples prepared under different gas pressure in the working chamber. It can be seen that films contain the features found in a-SiC:H: the Si–C stretching modes at 700–800 cm^{-1}, the Si–H stretching modes at about 2100 cm^{-1}, and the C–H stretching modes at about 2900 cm^{-1}. These results indicate small difference only at the C–H stretching modes. The amount of hydrogen increases with increasing pressure, and is bonded in C–H bonds.

The hydrogen content was determined by the ERD method. In Figure 2 are plotted ERD spectra obtained from the deposited films which contain different amounts of incorporated hydrogen. ERD analyses show that the amount of incorporated H rose from 10 to 15 at%. These values were obtained by computer modeling of measured spectra, and compared with the results obtained from a Si reference sample implanted with H. Results from ERD measurements correspond with the result from IR measurement where the hydrogen content is computed from the concentration of the Si–H and C–H bonds.

*Paper based on that presented at the 9th International School on Vacuum Electron and Ion Technologies, 14–17 September 1995, Sozopol, Bulgaria

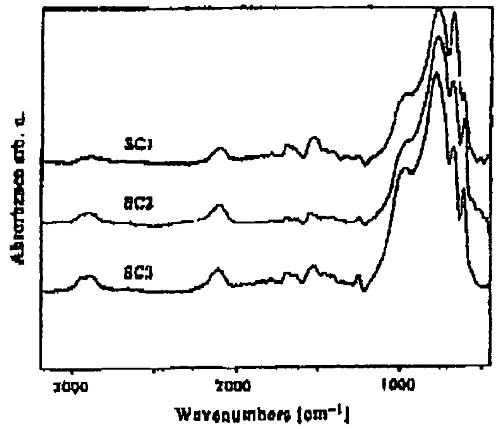

Figure 1. The IR spectra of plasma deposited amorphous silicon carbide films with chamber pressure during deposition for samples: SC1 (P = 60 Pa), SC2 (P = 100 Pa), SC3 (P = 150 Pa)

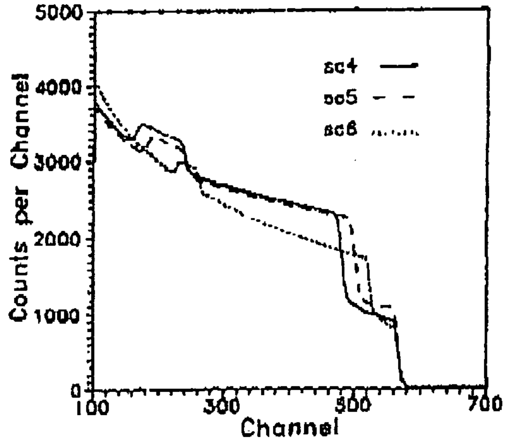

Figure 3. Smoothed RBS data for 2 MeV alfa particles detected at a scattering angle of 170°. The three curves are for samples SC4 (thickness of film 90 nm), SC5 (120 nm) and SC6 (170 nm).

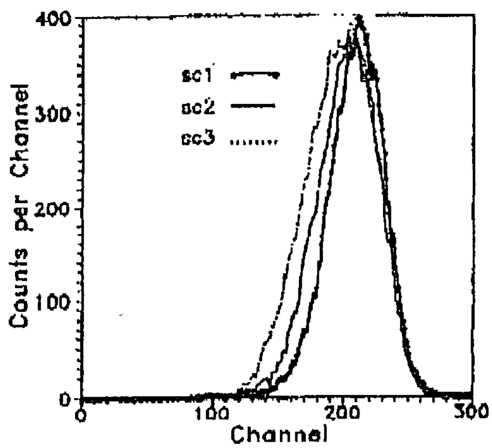

Figure 2. The ERD spectra of recoiled hydrogen obtained with 2.4 MeV $^4He^+$. The concentration of hydrogen for samples SC1, SC2, and SC3 are 11, 12, 15 at%, respectively.

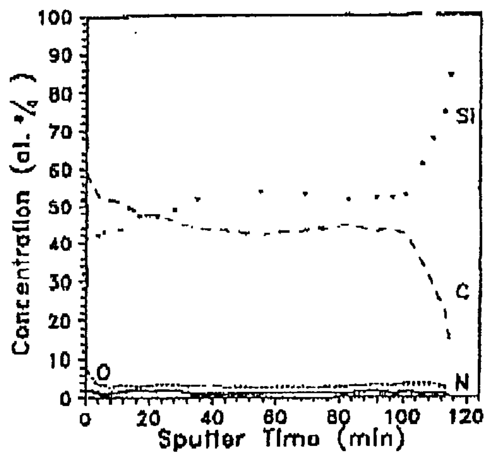

Figure 4. The AES depth profile for a amorphous silicon carbide film of sample SC5.

Figure 3 shows the RBS spectra for three samples of different thickness of the deposited amorphous silicon carbide films. The spectra were smoothed out for better identification of differences. Differences are practically at the place that represents concentration of carbon vs silicon and thickness of film. Typical concentrations were for silicon 40 at% and carbon 45 at%.

Figure 4 shows an AES depth profile of sample SC5. The concentration of silicon and carbon are approximately the same, which differs from the concentrations obtained from RBS measurements and probably arises from accuracy of measurement. Small amounts of oxygen and nitrogen were present in the films at concentrations up to 1 or 2%, respectively. More carbon was detected on the surface than in the volume of film and this carbon is probably from the external environment. At a sputter time of 100 min the interface between the substrate and film, begins to appear.

Conclusion

The structural properties of amorphous silicon carbide films prepared by PECVD have been investigated. The IR spectra show the presence of Si–C, Si–H, C–H bonds. The concentration of hydrogen determined by ERD is 10–15 at%. The RBS and AES

results show that concentrations of Si and C are almost equal. The concentrations of other elements such as oxygen and nitrogen are very small. The results indicate that the properties of amorphous carbon films depend upon the reaction conditions. The Si/C ratio determines film properties, but the hydrogen content and the chemical bonding pattern play an important role, which cannot be ignored when considering film properties.

References

[1] D A Anderson and W E Spear, *Philos Mag*, 35, 1 (1976).
[2] E G Wang, *Physica* B 185, 85 (1993).
[3] S Nakano, Y Kishi, M Ohnishi, S Tsuda, H Shibuya, N Nakamura, Y Hishikawa, H Tarui, T Takahama und Y Kuwano, *Mater Res Soc Symp Proc*, 49, 275 (1985).
[4] J Huran, P Szalmyi and E Pincovicova, *Acta phys slov* 39, 116 (1990).

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No
PCT/FR2004/001486

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1 Statement

Novelty (N)	Claims	1-10	YES
	Claims		NO
Inventive step (IS)	Claims	1-10	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-10	YES
	Claims		NO

2 Citations and explanations:

1 Reference is made to the following documents in the present notification:

D1: WO 00/47290 A (DIAMONEX INC) 17 August 2000 (2000-08-17)

D2: US 5 900 289 A (HARTMANN ROLF ET AL) 4 May 1999 (1999-05-04)

2 Document D1, which is considered to represent the most relevant prior art, describes (the references between parentheses apply to this document):

a coating for a mechanical part, comprising at least one outer layer of hydrogenated amorphous carbon (DLC) and a layer of silicon-doped hydrogenated amorphous carbon,

from which the subject matter of independent claim 1 differs in that:

the claimed coating does not explicitly comprise a layer of silicon-doped hydrogenated amorphous carbon, but a layer of hydrogenated amorphous silicon carbide.

Hydrogenated amorphous silicon carbide is distinguished essentially from silicon-doped hydrogenated amorphous carbon in that it contains not C-C bonds but rather Si-C, C-H and Si-H bonds.

2.1 The subject matter of claim 1 is therefore novel (PCT Article

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No
PCT/FR2004/001486

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

33(2)).

The problem to be solved by the present invention can be considered to be:

to produce a coating suitable for ideal adhesion to a mechanical part which may have any type of shape, and which is capable of stability at high temperatures, preferably greater than 250°C, and which has high anti-wear and anti-friction properties.

2.2 The solution to this problem, as proposed in claim 1 of the present application, is considered to involve an inventive step (PCT Article 33(3)), for the following reasons:

the solution proposed cannot be deduced from the available prior art documents, either alone or in combination, given that these documents do not describe a stack comprising a layer of hydrogenated amorphous silicon carbide, but a layer of silicon-doped hydrogenated amorphous carbon.

2.3 Claims 2-7 are dependent on claim 1 and thus also comply, as such, with the requirements of novelty and inventive step of the PCT.

3 Since the coating which is the subject matter of claims 1-7 is novel and inventive, the process for producing it, which is the subject matter of claims 8-10, is likewise novel and inventive.